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14. ABSTRACT In January 2007, China successfully tested a direct-ascent anti-satellite (ASAT) weapon, launching a kinetic kill vehicle staged atop a ballistic missile to destroy an aging weather satellite orbiting 537 miles above earth. Though not the first such test US space agencies had detected nor necessarily the most aggressive, as Air Force Chief of Staff General T. Michael Moseley explained to members of the Senate Armed Services Committee, the January test confirmed China "can attrit and literally kill satellites." Few would counter the assertion space systems have become critical to the efficacy of the instruments of national power, but to what extent do capabilities such as those demonstrated by China's ASAT testing threaten the successful conduct of the nation's diplomatic, information, military, and economic activities? This paper specifically seeks to determine whether a potential adversary's ability to conduct counterspace operations makes space power a critical vulnerability of the US military. Iraq's 2003 counterspace operations provide proof positive the unchallenged space superiority the US military has enjoyed since Desert Storm can no longer be taken for granted. The United States' disproportionate dependence on highly vulnerable space systems provides its enemies a recognizable opportunity to degrade the effectiveness of American forces that they are increasingly willing and capable of exploiting. By incorporating threat-based considerations into operational plans, wargames, and exercises, theater commanders can better prepare their forces for the operational implications of "war in space."					
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Space power: A Critical Strength...and a Critical Vulnerability of the US Military

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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10 May 07

Abstract

In January 2007, China successfully tested a direct-ascent anti-satellite (ASAT) weapon, launching a kinetic kill vehicle staged atop a ballistic missile to destroy an aging weather satellite orbiting 537 miles above earth. Though not the first such test US space agencies had detected nor necessarily the most aggressive, as Air Force Chief of Staff General T. Michael Moseley explained to members of the Senate Armed Services Committee, the January test confirmed China “can attrit and literally kill satellites.”

Few would counter the assertion space systems have become critical to the efficacy of the instruments of national power, but to what extent do capabilities such as those demonstrated by China’s ASAT testing threaten the successful conduct of the nation’s diplomatic, information, military, and economic activities? This paper specifically seeks to determine whether a potential adversary’s ability to conduct counterspace operations makes space power a critical vulnerability of the US military.

Iraq’s 2003 counterspace operations provide proof positive the unchallenged space superiority the US military has enjoyed since Desert Storm can no longer be taken for granted. The United States’ disproportionate dependence on highly vulnerable space systems provides its enemies a recognizable opportunity to degrade the effectiveness of American forces that they are increasingly willing and capable of exploiting. By incorporating threat-based considerations into operational plans, wargames, and exercises, theater commanders can better prepare their forces for the operational implications of “war in space.”

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Introduction

On January 11, 2007, Robert Joseph, Under Secretary of State for Arms Control and International Security, appeared before an audience at the Center for Space and Defense Studies to promote President Bush's recently released National Space Policy.¹ During his remarks, Secretary Joseph highlighted the importance of space systems to US national security and economic interests as well as the Government's concern over emerging threats to those systems and "the possibility others [might] take advantage of [the United States'] dependence on, and vulnerability in space to seek asymmetrical advantages over [the nation]."² Later that same day in what now seems an almost uncanny coincidence, China successfully tested a direct-ascent anti-satellite (ASAT) weapon, launching a kinetic kill vehicle staged atop a ballistic missile to destroy an aging weather satellite orbiting 537 miles above earth.³ Perhaps even more coincidentally, China conducted this test exactly six years after the release of the report of the Commission to Assess United States National Security Space Management and Organization,⁴ which warned that an attack on US space assets during times of crisis or conflict "should not be considered an improbable act."⁵

¹ President Bush authorized a new National Space Policy on 31 August 2006. An unclassified summary of the policy is available online at: <http://www.ostp.gov/html/US%20National%20Space%20Policy.pdf>.

² Robert G. Joseph, Under Secretary for Arms Control and International Security, US Department of State ("Remarks on the President's National Space Policy—Assuring America's Vital Interests," Center for Space and Defense Studies, Colorado Springs, CO, 11 January 2007).

³ Craig Covault, "Space Control: China's Asat Test Will Intensify US-Chinese Faceoff in Space," *Aviation Week & Space Technology* 166 (22 January 2007), 24, <http://www.proquest.com/> (accessed 6 April 2007).

⁴ Commonly referred to as the "Space Commission Report." A complete copy of the report is available online at: http://space.au.af.mil/space_commission/.

⁵ Commission to Assess United States National Security Space Management and Organization, *Report of the Commission to Assess United States National Security Space Management and Organization: Executive Summary* (Washington, DC, 11 January 2001), 8.

In addition to drawing the ire of the international community because of the immense debris field it created,⁶ the Chinese ASAT test also sent a tremor through the US national security community. Though not the first such test US space agencies had detected nor necessarily the most aggressive,⁷ as Air Force Chief of Staff General T. Michael Moseley explained to members of the Senate Armed Services Committee in March, the January test confirmed China “can attrit and literally kill satellites.”⁸

Research Question

Few would counter Secretary Joseph’s assertion space systems have become critical to the efficacy of the instruments of US national power, but to what extent do capabilities such as those demonstrated by China’s ASAT testing threaten the successful conduct of the nation’s diplomatic, information, military, and economic activities? More germane to this paper, does a potential adversary’s ability to conduct counterspace operations make space power a critical vulnerability of the US military?⁹ If so, what are the operational implications

⁶ The US Space Surveillance Network detected more than 1,000 new pieces of space debris following the Chinese ASAT test. See Gen Kevin Chilton, Commander, US Air Force Space Command (“Testimony,” US Congress, House Committee on Armed Services, 110th Congress, 1st Sess., 23 March 2007).

⁷ In late 2006, the Pentagon confirmed China had engaged US reconnaissance satellites orbiting over Chinese territory with a ground-based laser (see Reuters, “China Jamming Test Sparks US Satellite Concerns,” USA Today.com, posted 5 October 06 (accessed 6 April 2007)).

⁸ Gen T. Michael Moseley, Chief of Staff, US Air Force (“Testimony,” US Congress, Senate Committee on Armed Services, 110th Congress, 1st Sess., 20 March 2007), quoted in “Air Force Mulls How to Defend Space Assets, Wynne Says,” *Space & Missile Defense Report* 8 (26 March 2007), <http://web.lexis-nexis.com/> (accessed 4 April 2007).

⁹ **Counterspace operations:** Those offensive and defensive operations conducted by air, land, sea, space, special operations, and information forces with the objective of gaining and maintaining control of activities conducted in or through the space environment (see Air Force Doctrine Document (AFDD) 2-2, *Space Operations*, 27 November 2006). **Space power:** The total strength of a nation’s capabilities to conduct and influence activities to, in, through, and from space to achieve its objectives (see Joint Publication (JP) 3-14, *Joint Doctrine for Space Operations*, 9 August 2002). **Critical vulnerability:** An aspect of a critical requirement which is deficient or vulnerable to direct or indirect attack that will create decisive or significant effects (see JP 3-0, *Joint Operations*, 17 September 2006).

for theater commanders and what actions should they take to mitigate the impact of challenges to US space superiority?¹⁰

Thesis

Given the US military's growing dependence on the asymmetric advantages of space power, the inherent vulnerability of space systems, and the ever-expanding threat posed to those systems, space power has indeed become a critical vulnerability that, if exploited by an adversary, could significantly degrade or disrupt the conduct of joint military operations.

Accordingly, during the contingency and crisis action planning processes theater commanders should consider their level of dependence on space support as well as their enemies' abilities to deny them such support and develop appropriate mechanisms to mitigate the impact of hostile actions against friendly space capabilities. Further, commanders should wargame realistic adversary space denial and degradation scenarios and include like events in major theater operational and tactical exercises.

Scope of Study/Terms of Reference

Theater commanders are ultimately responsible for establishing and maintaining space superiority in their assigned areas of operation;¹¹ however, the Unified Command Plan establishes United States Strategic Command (USSTRATCOM) as the functional unified command with overall responsibility for military space operations.¹² The Commander, USSTRATCOM executes this mission through a subordinate joint task force-like entity, the Joint Force Component Command (JFCC) Space, which is charged with employing joint

¹⁰ **Space superiority:** The degree of dominance in space of one force over another that permits the conduct of operations by the former and its related land, sea, air, space, and special operations forces at a given time and place without prohibitive interference by the opposing force (see JP 3-14).

¹¹ US Air Force, *Counterspace Operations*, AFDD 2-2.1 (Washington, DC: Department of the Air Force, 2 August 2004), 12.

¹² AFDD 2-2, *Space Operations*, 10.

space forces for missile warning, precision navigation and timing, communications, spacelift, and counterspace operations in support of all combatant commands.¹³ The Commander, JFCC Space conducts counterspace operations in particular to ensure freedom of action in space for friendly forces; these operations collectively fall within the “space control” mission area.¹⁴ Though space control efforts form the bedrock upon which space superiority is built, because theater commanders play a somewhat limited role in their execution under current command and control relationships these activities fall outside the scope of this study.

Space power: A Critical Strength of the US Military...

Since making its first significant contributions at the operational and tactical levels of war during Operation Desert Storm, space power has become increasingly integrated into joint military operations. In a January 2006 article for *Military Review*, Lieutenant General Larry Dodgen, Commanding General, US Army Space and Missile Defense Command, notes, “In the decade since [Desert Storm], the value of space capabilities has grown significantly...military operations have moved from being supported by space assets to being space-enabled.”¹⁵ Not to diminish the significance of General Dodgen’s remarks, as highlighted in the introduction to this work the notion that space capabilities have become key elements of US military power is by no means a revelation. Space force enhancement operations—intelligence, surveillance, and reconnaissance (ISR); integrated tactical warning and attack assessment; environmental monitoring; communications; and position, velocity, time, and navigation—*clearly* provide an asymmetric advantage upon which US warfighters have become increasingly dependent when conducting activities across the range of military

¹³ Ibid.

¹⁴ JP 3-14, *Joint Doctrine for Space Operations*, IV-5. AFDD 2-2.1, *Counterspace Operations*, 2-3.

¹⁵ Larry J. Dodgen, “Space: Inextricably Linked to Warfighting,” *Military Review* 86 (January/February 2006), <http://www.proquest.com/> (accessed 21 February 2007).

operations. However, it is the *extent* to which space systems and space-based applications enable the modern American way of war—principally through these force enhancement efforts—that makes space power a critical strength¹⁶ of the US military—a preliminary point key to the premise of this paper.

Space Force Enhancement: An Asymmetric Advantage of the US Military

In joint terms, space systems have become critical requirements; that is, they are essential resources that ensure the critical capabilities of the US military are fully operational, in turn allowing the armed forces to function as an operational center of gravity.¹⁷ Space-based ISR systems once employed almost exclusively at the national-strategic level now provide warfighters at all levels a previously unimaginable degree of battlespace awareness and are integral to “the most reliable and secure” of the current US blue force tracking (BFT) architectures.¹⁸ Cold War-era Defense Support Program (DSP) satellites not only provide the backbone of the US strategic missile warning system, but also cue theater missile warning assets and have proven invaluable to modern combat search and rescue efforts.¹⁹ Space-based environmental monitoring systems like the Defense Meteorological Satellite Program (DMSP), which rose to prominence during Vietnam and continues to serve as the US military’s *only* “assured source of global weather data,”²⁰ remain unique in their ability to

¹⁶ **Critical strength:** Those military and nonmilitary capabilities considered essential to the accomplishment of one’s or the enemy’s military objective(s); in joint terms a critical requirement (see Vego, *Operational Warfare*).

¹⁷ **Center of gravity:** The source of power that provides moral or physical strength, freedom of action, or will to act (see JP 3-0). **Critical capabilities:** Those means that are considered crucial enablers for a center of gravity to function as such and are essential to accomplishment of the specified or assumed objective(s) (see JP 3-0).

¹⁸ US Army, *Space Support to Army Operations*, Field Manual (FM) 3-14 (Washington, DC: Department of the Army, 18 May 2005), B-2.

¹⁹ During Operation Iraqi Freedom, DSP operators assisted in the rescue of a Navy F-14 crew whose plane had crashed in an unidentified area of Southern Iraq. The Tomcat crew was rescued within 100 minutes of its ejection due in large part to the DSP constellation’s infrared detection capabilities, which had identified the heat signature emanating from the plane’s crash site (see Kitfield, “Weapons in the High Heavens,” and Hebert, “High Anxiety”).

²⁰ *Janes Search*, s.v. “DMSP,” <http://www.8janes.com/Search> (accessed 15 April 2007).

offer decision makers continually updated environmental information regarding remote or denied areas²¹ and in their capacity for supplementing traditional ISR collection platforms through employment of onboard multi-spectral imaging sensors.²² Military and commercial space-based satellite communications (SATCOM) systems fulfill the massive bandwidth requirements of modern military operations, moving volumes of information and communications and enabling new operational concepts like “reach back” and “reach forward”²³ as well as command and control of cutting-edge weapon systems like the Predator unmanned aerial vehicle (UAV). And perhaps no space system has revolutionized warfare to the extent of the Global Positioning System (GPS), which in addition to providing critical data for precision navigation and weapons employment has been integrated into innumerable military applications ranging from worldwide logistics tracking systems to tactical-use aircrew survival and evasion radios.

The US Military’s Growing Dependence on Space Power

As Everett Dolman of the Air Force School for Advanced Air and Space Studies points out in the Winter 2006 edition of *SAIS Review*, even a casual review of the appropriate statistics reveals the tremendous growth in the US military’s dependence on space systems from Desert Storm to Operation Iraqi Freedom.²⁴ For example, Iraqi Freedom used 42 times the space-based communications bandwidth of Desert Storm while employing a force less

²¹ JP 3-14, *Joint Doctrine for Space Operations*, C-2.

²² US Air Force, “Defense Meteorological Satellite Program Fact Sheet,” <http://www.af.mil/factsheets> (accessed 15 April 2007). David Perlman, “Revolutionary Satellites Aid US Military,” *NationalGeographic.com*, posted 17 October 01 (accessed 13 April 2007).

²³ Everett C. Dolman, “US Military Transformation and Weapons in Space,” *SAIS Review* XXVI, no. 1 (Winter-Spring 2006): 165.

²⁴ *Ibid.*

than half the size.²⁵ The dramatic increase in basic GPS applications between the two operations is equally staggering:

“In Desert Storm, 90 percent of munitions used were unguided. Of the 10 percent that were guided, none was GPS capable. By Iraqi Freedom, 70 percent were precision guided, more than half of those from GPS satellites. In Desert Storm, fewer than five percent of aircraft were GPS equipped. By Iraqi Freedom *all* were. During Desert Storm, GPS proved so valuable to the Army that it procured and rushed into theater over 4,500 *commercial* receivers...an average of one per company (about 200 personnel). By Iraqi Freedom, each Army squad (6-10 soldiers) had *at least* one *military* GPS receiver.”²⁶

While the preceding paragraphs outline the critical functions space assets perform in support of the modern joint force, this data highlights a reliance upon space systems that potential adversaries view as the “soft underbelly” of the US military.²⁷ As evidence of this perception, Dr. Joan Johnson-Freese of the Naval War College and Tom Wilson, a staff member for the Space Commission, cite a July 2000 Chinese newspaper report, which suggested, “For countries that could never win a war by using the method of tanks and planes, attacking the US space system may be an irresistible and most tempting choice....”²⁸ Joint Vision 2020 identifies “[t]he potential of such asymmetric approaches [as] perhaps the most serious danger the United States faces in the immediate future.”²⁹

...and a Critical Vulnerability

As previously noted, critical vulnerabilities are those aspects of one’s critical requirements that are susceptible to a direct or indirect attack that will create effects disproportionate to the resources applied. The US military’s demonstrated dependence on

²⁵ Dodgen, “Space: Inextricably Linked to Warfighting.”

²⁶ Dolman, “US Military Transformation and Weapons in Space,” 165.

²⁷ Andrew Plieninger, “All Along the Watchtower: Safeguarding American Space Dominance,” *Ad Astra* (Fall 2005), <http://firstsearch.oclc.org/> (accessed 4 April 2007).

²⁸ Joan Johnson-Freese, “China’s Manned Space Program: Sun Tzu or Apollo Redux?” *Naval War College Review* 56 (Summer 2003), <http://www.proquest.com/> (accessed 22 February 2007). Tom Wilson, “Threats to United States Space Capabilities,” <http://www.fas.org/spp/eprint/article05.html> (accessed 12 April 2007).

²⁹ Chairman, US Joint Chiefs of Staff, Joint Vision 2020 (Washington, DC: CJCS, 30 May 2000), 5.

space systems coupled with the inherent vulnerability of those systems presents just such an opportunity for those hostile to the United States to degrade the effectiveness of its fielded forces.

Major David Meteyer of the Naval Postgraduate School outlines the vulnerability of space assets in a 2005 occasional paper for the Institute for National Space Studies:

“...the multiple elements necessary to operate space systems [i.e., the satellites and associated ground stations as well as the communications signals that link them³⁰] make them more vulnerable than other, more traditional weapon systems. Therefore, while space operations are critical, they are also vulnerable, and while US forces are highly dependent upon these systems, they are not well protected nor easily replaced.”³¹

Air Force doctrine governing counterspace operations confirms Major Meteyer’s assertion:

“The US military is dependent on the use of space capabilities in all types of warfare to maintain a combat advantage over [its] adversaries. With rare exception, today’s space infrastructure is largely unprotected. Space capabilities...could be prime targets for hostile exploitation and attack.”³²

USSTRATCOM Commander General James Cartwright amplified this perspective in response to questions submitted in advance of his 2004 Senate confirmation hearings, identifying system vulnerabilities among the top five most significant challenges facing US military space programs.³³ Such concerns are well founded—as noted in the 2001 Space Commission Report:

“[t]hose hostile to the United States possess, or can acquire on the global market, the means to *deny, disrupt or destroy* [emphasis added] US space systems by attacking satellites in space, communications links to and from the ground or ground stations that command the satellites and process their data.”³⁴

³⁰ JP 3-14, *Joint Doctrine for Space Operations*, I-1.

³¹ David O. Meteyer, *The Art of Peace: Dissuading China from Developing Counter-Space Weapons*, INSS Occasional Paper 60 (USAF Academy, CO: USAF Institute for National Security Studies, 2005), 53.

³² AFDD 2-2.1, *Counterspace Operations*, 1.

³³ Gen James E. Cartwright, Commander, US Strategic Command (“Advance Questions,” US Congress, Senate Committee on Armed Services, 108th Congress, 2nd Sess., July 2004).

³⁴ Commission to Assess United States National Security Space Management and Organization, *Report of the Commission to Assess United States National Security Space Management and Organization: Executive Summary*, 8.

Ground-based lasers (GBLs), direct-ascent ASAT weapons, high-altitude nuclear explosions, and “hunter-killer” or “parasitic” microsatellites all threaten orbiting space assets, while electronic and conventional attack can affect corresponding signal links and ground stations.

Threats to Satellites

“Capable of temporarily or permanently degrading or destroying satellite subsystems,”³⁵ GBLs offer a subtle but highly effective means of satellite engagement.³⁶ Though National Reconnaissance Office Director Donald Kerr reports the Chinese laser “dazzling” of a US reconnaissance satellite disclosed by the Pentagon in late 2006 “did not materially damage the satellite’s ability to collect information,”³⁷ Jonathan Lockwood of *Defense & Foreign Affairs Strategic Policy* estimates “20 to 30 nations” have access to technology similar to that employed in a 1997 US experiment during which a low-power ground-based tracking laser *was in fact* able to *significantly* disrupt the operation of an orbiting satellite.³⁸

Dr. Johnson-Freese suggests ground-based direct-ascent ASAT weapons employed in either a kinetic fashion, such as in China’s January test, or launched to deploy destructive objects into a satellite’s path offer the “easiest way to attack and destroy a satellite.”³⁹ She estimates more than a dozen countries have the capability to build such a system.⁴⁰

³⁵ AFDD 2-2.1, *Counterspace Operations*, 4.

³⁶ Thomas A. Summers, “How is US Space Power Jeopardized by an Adversary’s Exploitation, Technological Developments, Employment and Engagement of Laser Antisatellite Weapons?” (Research paper, Maxwell AFB, AL: US Air Command and Staff College, 2000), 18.

³⁷ Reuters, “China Jamming Test Sparks US Satellite Concerns.”

³⁸ Jonathan S. Lockwood, “Space Control versus Space Denial in 21st Century Warfare: Achilles Heel of the RMA?” *Defense & Foreign Affairs Strategic Policy* 28 (August 2000), <http://www.proquest.com/> (accessed 5 April 2007).

³⁹ Joan Johnson-Freese, “‘Houston, we have a problem’: China and the Race to Space.” *Current History* 102 (September 2003), <http://www.proquest.com/> (accessed 22 February 2007).

⁴⁰ Ibid.

Writing for *Ad Astra*, Andrew Plieninger identifies high-altitude nuclear explosions as a “relatively simple, well-known and devastating means” of attack against orbiting space assets, stating “[d]etonation over any point on the globe will promptly disable all satellites within line-of sight and render virtually all unhardened satellites in Low Earth Orbit (LEO) useless within two months.”⁴¹ Testifying before the House Armed Services Committee in June 2006, Michael O’Hanlon of the Brookings Institution, agreed “[v]irtually any country capable of putting a nuclear weapon into LEO [e.g., Russia, China, India and potentially North Korea and Iran] has a latent anti-satellite capability.”⁴²

According to a report in the *Sing Tao Daily*, in January 2001 China completed ground testing of a “nanometer-sized ‘parasitic satellite,’”⁴³ which when deployed from a “carrier” is capable of attaching itself to a target satellite and remaining latent until issued commands to interfere with or destroy its host.⁴⁴ Gregory Kulacki, a China Specialist for the Union of Concerned Scientists, claims reports of such an ASAT capability are baseless;⁴⁵ however, both the 2005 and 2006 editions of the *Department of Defense Annual Report to Congress on the Military Power of the People’s Republic of China* highlight China’s pursuit of small and microsatellites.⁴⁶ Further, the Air Force Research Laboratory’s Experimental Satellite Series (XSS) of microsatellites has demonstrated capabilities similar to those attributed to the Chinese parasitic satellites. In fact, in an article for the *Air and Space Power Journal*

⁴¹ Plieninger, “All Along the Watchtower.”

⁴² Michael O’Hanlon (“Testimony,” US Congress, House Committee on Armed Services, 109th Congress, 2nd Sess., 21 June 2006).

⁴³ Nanometer sized satellites generally weigh between 1-10 kilograms (see Federation of American Scientists, “Ensuring America’s Space Security”).

⁴⁴ Quoted in Cheng Ho, “China Eyes Antisatellite System,” SpaceDaily.com, <http://www.spacedaily.com/news/china-01c.html> (accessed 12 April 2007).

⁴⁵ Gregory Kulacki. (Conference lecture, The George Washington University, Washington, DC, 12 May 2005).

⁴⁶ US Office of the Secretary of Defense, *Annual Report to Congress: The Military Power of the People’s Republic of China 2005*, (Washington, DC, 2005), 35. US Office of the Secretary of Defense, *Annual Report to Congress: The Military Power of the People’s Republic of China 2006*, (Washington, DC, 2006), 35.

Captain Joseph Page identified the on-orbit XSS-11 as a potential prototype for parasitic satellite attitude control systems.⁴⁷

Threats to Satellite Communications Links

In a paper prepared for the Space Commission, Tom Wilson explains all military and commercial satellites are to some degree susceptible to electronic attack;⁴⁸ more specifically, radio frequency (RF) “jamming”⁴⁹ of the communications links that beam satellite data down to a user or controlling ground station (the downlink), or of the links that transmit data up to the satellite from a user or controlling ground station (the uplink). Noting the relative ease with which satellite communications links can be attacked, Michael O’Hanlon reports Air Force Research Laboratory engineers “homebuilt” an effective Ultra High Frequency (UHF) SATCOM jammer “using about \$7,500 worth of goods bought at electronics and hardware stores.”⁵⁰

During Iraqi Freedom, Iraq’s air defense forces deployed six Russian-made GPS downlink jamming devices around Baghdad in an attempt to reduce the accuracy of coalition precision-guided munitions.⁵¹ In a 2000 article for *Aviation Week & Space Technology*, James Asker notes Iraq employed similar jammers against coalition aircraft during Operation Northern Watch⁵² and it is possible like devices have been sold to Iran, Egypt, Serbia, and

⁴⁷ Joseph T. Page II, “Stealing Zeus’s Thunder: Physical Space Control Advantages against Hostile Satellites,” *Air & Space Power Journal* XX, no. 2 (Summer 2006): 33.

⁴⁸ Wilson, “Threats to United States Space Capabilities.”

⁴⁹ At the most basic level, jamming is the transmission of signals that interfere with the operation of a satellite or its payload (see Jeffrey Lewis, “False Alarm on Foreign Capabilities”).

⁵⁰ O’Hanlon, *Testimony*. 527th Space Aggressor Squadron (527 SAS) “Mission Brief,” Powerpoint, Nellis AFB, NV, <http://www.swc.spacecom.smil.mil> (accessed 27 April 2007).

⁵¹ Jeremy Singer, “US-led Forces Destroy GPS Jamming Systems in Iraq,” Space.com, http://www.space.com/news/gps_iraq_030325.html, posted 25 March 2003 (accessed 1 March 2007).

⁵² James R. Asker, “Anti-Anti-GPS.” *Aviation Week & Space Technology* 153 (20 November 2000), <http://www.proquest.com/> (accessed 13 April 2007).

Vietnam.⁵³ Though largely ineffective,⁵⁴ James Canan of *Aerospace America* points out, “Iraq’s use of electronic countermeasures…[is] an ominous portent of possibly higher-powered jamming by better-equipped, more adept adversaries in conflicts to come.”⁵⁵

Though technically more complex than downlink jamming,⁵⁶ uplink jamming has been quite pervasive in recent years as well. In 2003, Cuba successfully jammed a Voice of America-sponsored Persian-language television news program being broadcast to Iran on a US commercial communications satellite deemed to be the most technically advanced of its series.⁵⁷ The governments of Indonesia, Turkey, Libya, and Israel have all allegedly conducted similar jamming efforts, as has the Chinese Falun Gong movement.⁵⁸

Threats to Space System Ground Segments

As Robert Ackerman points out in a June 2005 article for *Signal*, “Critical ground facilities [e.g., satellite communications, data reception, and command and control sites⁵⁹] associated with US space systems can be struck by organized terrorists or by foreign special operations forces” rather easily.⁶⁰ General Dodgen confirms, “the ground segments of [US] space systems are particularly vulnerable to a conventional attack,”⁶¹ because many such facilities are described in great detail in open-source material, attacks upon which, if

⁵³ 527 SAS, *Mission Brief*.

⁵⁴ Iraq’s GPS jamming devices were destroyed by two B-1 bombers, employing, ironically, GPS-aided munitions (see Rivers, “USAF General Stresses Importance of Space”).

⁵⁵ James W. Canan, “Controlling the Space Arena,” *Aerospace America* (January 2004), <http://web.lexis-nexis.com/> (accessed 23 February 2007).

⁵⁶ Uplink jammers must be at least as powerful as the emitter associated with the link being jammed; to the contrary, downlink jammers can be much less powerful and still be effective (see Wilson, “Threats to United States Space Capabilities”).

⁵⁷ J. Michael Waller, “Iran and Cuba Zap US Satellites,” *Insight on the News* (19 August 2003), <http://www.findarticles.com/> (accessed 23 February 2007).

⁵⁸ 527 SAS, *Mission Brief*.

⁵⁹ National Air and Space Intelligence Center, *Challenges to US Space Superiority*, (Wright-Patterson AFB, OH, March 2005), 19.

⁶⁰ Robert K. Ackerman, “Space Vulnerabilities Threaten US Edge in Battle,” *Signal* (June 2005), <http://www.proquest.com/> (accessed 12 March 2007).

⁶¹ LTG Larry J. Dodgen, Commanding General, US Army Space and Missile Defense Command (“Testimony,” US Congress, House Committee on Armed Services, 109th Congress, 1st Sess., 9 March 2005).

successful, could certainly “disrupt, deny, degrade, or destroy the utility of the [entire] space system.”⁶² The coalition’s destruction of an Iraqi satellite television ground station during Iraqi Freedom, an operation that hampered Iraq’s communications and command and control capabilities, is an example of the military utility of an attack against a space ground segment.

US Commercial Satellite System Dependence and its Effect on Vulnerability

In its 2001 report, the Space Commission expressed concern over the US Government’s increasing dependence on the commercial space sector for provision of “essential services for national security operations.”⁶³ However, as highlighted in Air Force Doctrine Document (AFDD) 2-2, *Space Operations*, “during large-scale contingencies and combat operations” US military space capabilities, like other military resources, “will be stressed,” requiring the use of “civil, commercial, and/or foreign space assets to support military objectives.”⁶⁴ Air Force doctrine goes on to assert integration of such capabilities may even become vital to mission accomplishment in the future.⁶⁵

During Desert Storm, commercial systems provided only 20 percent of the requisite SATCOM;⁶⁶ however, that number rose to 60 percent during Operations Allied Force and Enduring Freedom⁶⁷ and to a high of 80 percent during Iraqi Freedom.⁶⁸ David Cavossa, Executive Director of the Satellite Industry Association, reports in 2005 alone “the [Department of Defense] spent over \$650 million on commercial satellite communications

⁶² National Air and Space Intelligence Center, *Challenges to US Space Superiority*, 19.

⁶³ Commission to Assess United States National Security Space Management and Organization, *Report of the Commission to Assess United States National Security Space Management and Organization: Executive Summary*, 8.

⁶⁴ AFDD 2-2, *Space Operations*, 35.

⁶⁵ *Ibid.*

⁶⁶ David Cavossa (“Testimony,” US Congress, House Committee on Armed Services, 109th Congress, 2nd Sess., 21 June 2006).

⁶⁷ Gen Ralph E. Eberhardt, Commander in Chief, North American Aerospace Defense Command and US Space Command (“Testimony,” US Congress, Senate Committee on Armed Services, 106th Congress, 2nd Sess., 8 March 2000). Dr. Ronald M. Sega, Under Secretary of the Air Force (“Testimony,” US Congress, House Committee on Armed Services, 109th Congress, 2nd Sess., 16 March 2006).

⁶⁸ Sega, “Testimony.”

equipment and capacity and is projected to spend over \$1 billion a year by 2010 on its expanding commercial satellite communications requirements.”⁶⁹ Though military SATCOM provides adequate bandwidth for most secure communications, sensitive operations, and strategic command and control, the command and control of the Predator UAV weapon system, for example, is completely reliant on a commercial SATCOM architecture when operating beyond line-of-sight,⁷⁰ as are many of the Army’s current BFT systems.⁷¹

The US military is equally dependent on commercial imagery providers. According to a 2003 article in *Washington Quarterly*, “During the first five months of Operation Enduring Freedom the Department of Defense paid the Space Imaging Corporation \$1.9 million per month for images of Afghanistan collected by its Ikonos imaging satellite.”⁷² Though some contend the Department purchased the Ikonos imagery to preclude others from accessing it, the Congressional Research Service reports “Congress has strongly encouraged [the National Geospatial-Intelligence Agency (NGA)] to purchase commercial imagery to augment classified imagery” obtained through national ISR assets.⁷³ The Department of Commerce confirms “the NGA will spend up to \$500 million over the next five years on commercial imagery...for use by various agencies of the federal government.”⁷⁴

This heavy reliance on commercial space providers, a trend likely to continue as “US military dependence on space systems...continue[s] to outpace DoD budget and production

⁶⁹ Cavossa, “Testimony.”

⁷⁰ *Janes Search*, s.v. ”Ku-Band Satellite Communications,” <http://www.8janes.com/Search> (accessed 30 March 2007).

⁷¹ FM 3-14, *Space Support to Army Operations*, B-2.

⁷² William C. Martel and Toshi Yoshihara, “Provocations,” *Washington Quarterly* (Autumn 2003), <http://web.lexis-nexis.com/> (accessed 22 February 2007).

⁷³ Marcia S. Smith, *US Space Programs: Civilian, Military, and Commercial*, (Washington, DC, 28 February 2005), 7.

⁷⁴ Edward Morris (“Testimony,” US Congress, House Committee on Armed Services, 109th Congress, 2nd Sess., 21 June 2006).

capability,”⁷⁵ further exacerbates America’s significant vulnerability in space. Unlike many military satellites, which offer some *limited* anti-jam capabilities, commercial satellites are *highly* susceptible to the full array of ASAT threats. Robert Dickman, Executive Director of the American Institute of Aeronautics and Astronautics and former Deputy for Military Space in the Office of the Undersecretary of the Air Force, notes commercial satellite providers have put themselves in “an attack circle” they simply may not have anticipated.⁷⁶

The Nexus: Dependence, Vulnerability, and a Credible Threat

In January 1997, the Army War College and US Army Training and Doctrine Command conducted a wargame as part of a larger effort to “identify and explore issues affecting the development of the Army in the next century.”⁷⁷ The 1997 Army After Next Winter Wargame pitted a Blue force heavily dependent on space assets against near-peer Red and Pink forces each of which, while possessing counterspace capabilities commensurate with those described in this paper, was considered technologically inferior to the Blue force.

Jonathon Lockwood, a writer and Red team member during the game, recalls:

“The Red leadership quickly recognized that directly challenging Blue’s [Revolution in Military Affairs (RMA)-style] forces on its own terms would be strategic suicide for Red. Red recognized that Blue’s space assets were the crucial ‘center of gravity’ for its RMA forces...[and] it would be necessary to mount a ‘space offensive’ from the outset to neutralize Blue’s space assets. This would break the crucial link in its RMA force structure, and thus slow down Blue’s reaction time enough for Red to achieve its objectives.

On day two...Red launched its offensive...while simultaneously initiating a ‘space offensive’ designed as part of its ‘space denial’ strategy against Blue’s RMA forces [specifically, its intelligence and communications satellites]. The results were dramatic...Blue’s RMA forces were completely paralyzed by the space offensive. In the words of one stunned Blue participant, ‘everything just ground to a halt.’”⁷⁸

⁷⁵ Adolfo J. Fernandez, *Military Role in Space Control: A Primer*, (Washington, DC, 23 September 2004), 3.

⁷⁶ Robert Dickman. (Conference lecture, The George Washington University, Washington, DC, 12 May 2005).

⁷⁷ Walter L. Perry and Marc Dean Millot, *Issues from the 1997 Army After Next Winter Wargame*, (Santa Monica, CA, 1998), ix.

⁷⁸ Lockwood, “Space Control Versus Space Denial in 21st Century Warfare: Achilles Heel of the RMA?”.

In recounting the outcome of the 1997 Winter Wargame, Lockwood outlines three key lessons learned identified by participants that are particularly cogent to the argument outlined in this paper. First, the vulnerability of space assets was a “critical weak link” to the Blue RMA forces. Second, neither Red nor Pink forces needed to control space to deny Blue its use. And third, “preemptive strikes in space...offered an attractive ‘asymmetric response’ for a technologically inferior opponent that wished to negate the advantages of an RMA force.”⁷⁹

A Counterargument: Few, if any, Truly Capable (and Willing) Enemies Exist

In addressing the Red force attack on Blue space assets during the 1997 Winter Wargame, the authors of the RAND report analyzing the game’s results identified a reality later echoed by former Space Commission chairman and then-Secretary of Defense Donald Rumsfeld: that no nation possessed either the necessary space order of battle or disregard for consequence to execute a “space Pearl Harbor” against US forces.⁸⁰ The Federation of American Scientists recognized the political dimension of such an attack in a 2004 study on space weaponization, noting “just because satellites are vulnerable to ground-based missiles, laser[s], or radiation from a high-altitude nuclear explosion, it does not mean that there are credible threats that might exploit these vulnerabilities.”⁸¹ Setting aside the political considerations associated with such an attack, *effective* counterspace operations, regardless of tactic employed, are also extremely complex and require a fundamental ability to “find, fix,

⁷⁹ Ibid.

⁸⁰ Perry and Millot, *Issues from the 1997 Army After Next Winter Wargame*, 11. Rumsfeld quoted in Lewis, “False Alarm on Foreign Capabilities.”

⁸¹ Federation of American Scientists, “Ensuring America’s Space Security,” <http://www.fas.org/main/content.jsp?formAction=297&contentId=311> (accessed online 4 April 2007).

and track space objects, signals, and terrestrial nodes”⁸² that is simply beyond the indigenous capability of even most space-faring nations.⁸³

A Brief Case Study: China, The Assassin’s Mace, and a Look at Operational Implications

In yet another somewhat coincidental twist on China’s recent ASAT activity, in its 2001 report the Space Commission identified a conflict in the Taiwan Straits as a crisis in which “the potential vulnerability of space systems would be worrisome.”⁸⁴ Echoing the Commission’s concerns, the 2005 and 2006 Department of Defense reports on China’s military power confirm the Asian nation has aims of developing “counters to third party, including potential US, intervention in cross-Strait crises” and “is in the process of long-term transformation from a mass army designed for protracted wars of attrition...to a more modern force capable of fighting short duration, high intensity conflicts against high-tech adversaries.”⁸⁵ In a February 2007 article for the *Taipei Times*, James Holmes outlines a complementary concept known as the “Assassin’s Mace” that embodies the traditional Chinese niche-capability approach to warfare which he describes as “...negating a superior enemy’s advantages by landing a single, sharp blow. The kind of blow that Chinese forces might strike against US warships with sea mines or stealthy submarines, or against satellites with ground-based interceptors or lasers.”⁸⁶ These assertions coupled with its recent ASAT activity clearly indicate China is considering, if not committed to, the concept for asymmetric

⁸² AFDD 2-2.1, *Counterspace Operations*, 22.

⁸³ Russia, China, France, Japan, and South Korea all reportedly have or are developing ground-based space object surveillance and identification sensors (see *Challenges to US Space Superiority*, 17).

⁸⁴ Commission to Assess United States National Security Space Management and Organization, *Report of the Commission to Assess United States National Security Space Management and Organization: Executive Summary*, 14.

⁸⁵ US Office of the Secretary of Defense, *Annual Report to Congress: The Military Power of the People’s Republic of China 2005*, i. US Office of the Secretary of Defense, *Annual Report to Congress: The Military Power of the People’s Republic of China 2006*, 1.

⁸⁶ James Holmes, “‘Assassin’s Mace’ is the PRC’s Key in New Race,” *Taipei Times*, 17 February 2007.

attack against US space forces highlighted in the July 2000 Chinese report cited earlier in this paper.

Given the US military's highlighted dependence on space systems and the demonstrated vulnerabilities of those systems, an effective Chinese space attack in the spirit of the Assassin's Mace—which it is *completely* capable of and apparently willing to conduct under the right circumstances—could at minimum degrade, or at worst disrupt, the responsible joint task force commander's ability to integrate, synchronize, and direct military operations using the operational functions outlined in joint doctrine.⁸⁷ For example, jamming of SATCOM links could hamper effective command and control. GBL engagement of orbiting ISR assets could preclude efficient intelligence collection and dissemination. GPS degradation could affect not only movement and maneuver, but also the employment of precision-guided munitions, limiting options for operational fires and potentially causing logistics problems. And finally, disruption of the space-based systems that link the DSP constellation with the Navy Aegis cruisers and Army Joint Tactical Ground Stations and Patriot Air Defense batteries likely to be operating in the vicinity of the Straits could create significant operational protection concerns given the nearly 800 ballistic missiles China reportedly has aimed at Taiwan.⁸⁸

Barring employment of a high-altitude nuclear explosion, it is unlikely even China could *completely* deny space support to the US military; however, in a Taiwan scenario many space functions would be critical to successful US intervention, any of which if degraded even moderately could significantly handicap US forces operating in the region. Open-

⁸⁷ The joint/operational functions are: command and control; intelligence, fires, movement and maneuver; protection; and sustainment (see JP 3-0).

⁸⁸ William M. Arkin, "America's New China War Plan," WashingtonPost.com, <http://blog.washingtonpost.com/earlywarning/2006/05>, posted 24 May 2006 (accessed 23 March 2007).

source reporting of China’s dogged pursuit of counterspace capabilities coupled with its demonstrated willingness to employ them should make mitigating the impact of space degradation a priority concern for US Pacific Command war planners.

Conclusions

While an attack commensurate with a “space Pearl Harbor” seems no more likely today than it might have been prior to release of the Space Commission report in 2001, the Commission’s concerns regarding the increasing US dependence upon space power and the vulnerabilities that dependence creates are significantly more compelling now than when its findings were originally published. Modern space capabilities no longer simply enhance, but in fact *enable* the effectiveness of today’s warfighters, providing them an asymmetric advantage of which potential adversaries have taken note. As the US military continues to integrate space assets and space-based applications into its doctrine, plans, and programs,⁸⁹ hostile actors remain focused on development, proliferation, and employment of *credible* threats that seek to not only negate the strength the United States derives from space, but to dramatically degrade the effectiveness of its armed forces by means of indirect attack against this critical vulnerability.

Recommendations

As prescribed in Joint Publication 3-14, *Joint Doctrine for Space Operations*, “commanders must anticipate hostile actions that attempt to deny friendly forces access to or use of space capabilities.”⁹⁰ At the operational level of war, commanders and their staffs can prepare for such challenges to space superiority by: 1) developing contingency and crisis

⁸⁹ Space-based capabilities enable the visions of all future network-centric operations, such as the Army’s Battle Command-on-the-Move and the Navy’s Sea Power 21, FORCEnet, and FORCEview concepts (see 2007 US Air Force Posture Statement).

⁹⁰ JP 3-14, *Joint Doctrine for Space Operations*, vii.

action plans that not only consider, but *mitigate* the impact of an enemy's abilities to attack supporting space systems; 2) wargaming realistic adversary space denial and degradation scenarios; and 3) including like events in major theater operational and tactical exercises.

Plans

Joint and service doctrine governing space operations adequately emphasizes the importance of integrating space assets into campaign planning, to include consideration of the belligerents' space orders of battle and their associated vulnerabilities as well as enemy threats to US space superiority and their potential employment.⁹¹ Certainly such a robust space input is key to the theater commander's grasp of the operational environment; however, beyond a passing reference in AFDD 2-2 there is no discussion of the need to prepare alternatives in the event friendly space capabilities are denied or degraded.

If an adversary presents a realistic counterspace threat, theater planners should, at minimum, consider developing branches from a campaign's base plan that account for the potential disruption of space support. Since many space-based capabilities are not necessarily unique to the medium,⁹² these branches could, among other possibilities, include requests for air-breathing forces that provide capabilities complementary to those provided by at-risk space systems.

Wargames

Another of the Space Commission's key findings pertained to the Department of Defense's failure to adequately wargame "the loss or temporary interruption of key space

⁹¹ See JP 3-14, *Joint Doctrine for Space Operations*, Chapter V; AFDD 2-2, *Space Operations*, Chapter 3; and FM 3-14, *Space Support to Army Operations*, Annex A.

⁹² AFDD 2-2, *Space Operations*, 3.

capabilities.”⁹³ The Air Force developed the “Schriever” series of wargames to address this concern at the national level; however, wargaming conducted to analyze friendly and enemy courses of action (COAs) developed at the operational level of war should also consider the impact of hostile counterspace operations. Rather than injecting Pearl Harbor-like attacks against friendly space systems as did the Red forces during the 1997 Army After Next Wargame, the “red cells” established to assist in evaluating the effectiveness of friendly COAs against red counterspace threats should do so from the same aggressive, but realistic perspective that pervades enemy COA development during intelligence preparation of the operational environment.

Exercises

In October 2000, the Air Force established the 527th Space Aggressor Squadron (527 SAS) to prepare service, joint, and allied forces for combat with space-capable adversaries with the intent of improving the ability of these forces to detect and mitigate the effect of enemy space use or attack.⁹⁴ The 527 SAS and its Air National Guard sister-squadron attempt to disrupt friendly military exercises by employing actual or simulated foreign space systems to jam supporting satellite communications links, providing targeted forces “their first taste of space combat.”⁹⁵

Regional combatant commanders employ the aggressor squadrons extensively during major theater operational and tactical exercises; however, the squadrons’ unique capabilities are often underutilized, as their activity is too often limited solely to red cell participation.

⁹³ Commission to Assess United States National Security Space Management and Organization, *Report of the Commission to Assess United States National Security Space Management and Organization: Executive Summary*, 29.

⁹⁴ 527 SAS, *Mission Brief*.

⁹⁵ Louis Arana-Barradas, “Lifeline to the Warfighter,” *Airman* 50 (Spring 2006), <http://www.proquest.com/> (accessed 23 February 2007).

To reap the full benefit of the aggressors' involvement, theater commanders should request more robust participation to include live-fire jamming that portrays realistic enemy counterspace capabilities. This degree of involvement would allow theater forces greater opportunity to experience and understand the effects of degraded or denied space support and better prepare them for operating in such environments.

Summary

Iraq's 2003 counterspace operations provide proof positive the unchallenged space superiority the US military has enjoyed since Desert Storm can no longer be taken for granted. The United States' disproportionate dependence on highly vulnerable space systems provides its enemies a recognizable opportunity to degrade the effectiveness of American forces that they are increasingly willing and capable of exploiting. By incorporating threat-based considerations into operational plans, wargames, and exercises, theater commanders can better prepare their forces for the operational implications of "war in space."

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